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**APPLICATION NUMBER: 60/542,271**

**FILING DATE: *February 04, 2004***

**RELATED PCT APPLICATION NUMBER: *PCT/US05/03767***



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INVENTOR(S)					
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<input type="checkbox"/> Additional inventors are being named on the ____ separately numbered sheets attached hereto					
TITLE OF THE INVENTION (280 characters max)					
SHEET MATERIAL INFILTRATION OF POWDER METAL PARTS					
Direct all correspondence to: CORRESPONDENCE ADDRESS					
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<input checked="" type="checkbox"/> Specification Number of Pages		5	<input type="checkbox"/> CD(s), Number		
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<input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76					
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT					
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Respectfully submitted,

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## **SHEET MATERIAL INFILTRATION OF POWDER METAL PARTS**

### **FIELD OF THE INVENTION**

This invention relates to manufacturing powder metal (PM) parts, and in particular to infiltration of PM parts with a material such as copper.

### **BACKGROUND OF THE INVENTION**

Infiltration is the process of filling the interconnected pores of a P/M compact with a molten metal or alloy of lower melting point by capillary action. Copper infiltrated steels are manufactured by compacting iron or iron-base powder (with or without graphite powder) into a finished shape and infiltrating the interconnected pores with a copper base material during the sintering operation. This may be a single pass or two stage infiltration. The result is a steel-copper structure unique to the powder metallurgy process. Compared with as-sintered iron or carbon steel P/M parts, copper infiltration can improve tensile strength, elongation, hardness, and impact properties.

In the past, the source of copper for infiltrating a PM part was a PM copper blank, i.e., a part made from copper powder that is pressed together to maintain its shape. The present invention provides an alternative to using a PM copper blank as the infiltration source, yielding the benefits described below.

### **SUMMARY OF THE INVENTION**

An infiltration process of the invention uses stamped copper sheet material as a source of copper for infiltration to achieve a high strength P/M steel article.

The advantages of utilizing copper sheet instead of a P/M copper blank are:

1. A reduction in the amount of residue remaining after infiltration;
2. A reduction in the amount of erosion of the base iron surface at the point of infiltrant entry;
3. Improved selective infiltration localization because the sheet stamping process facilitates shapes with geometry not practical via conventional powder metal infiltrant blanks such as thin webs, and missing area's;
4. Improved infiltration process quality due to the elimination of the breakage associated with fragile P/M infiltrant blanks; and

5. Improved positioning of the stamped copper sheet blanks due to the stamping processes' ability to form locating features to interlock with the component to be infiltrated.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Three infiltration techniques were compared vs a non-infiltrated control test. Standard test rings nominally 2.0" OD x 0.75" ID x 1.125" long were used, made of MPIF Std 35 FC-0208 material. The base compacts were pressed to a density of 6.95 g/cc. Eighteen test rings (18) were manufactured for the infiltration

The three infiltration techniques explored were:

1. Not infiltrated (control) based on MPIF Std 35 FC-0208;
2. Standard P/M copper infiltration as described in MPIF Std 35 (FX series) i.e. using powdered metal infiltrant material and pressing it to form a shape suitable to lay on the top of a P/M article for subsequent infiltration during sintering;
3. Dual feed process where powder was with MPIF FC-0208 material the die was then lowered and a second fill with infiltration material added and compacted; and
4. Infiltration using a copper stamping material (0.032 inches thick) cut using tin snips to produce a shaped copper source the same area as the test ring.

All test pieces were sintered in a 24" muffle furnace at normal sintering conditions (e.g., at 2050 F for 15 minutes in a 90% nitrogen, 10% hydrogen atmosphere). Figure 1 details the test pieces after sintering/infiltrating.

#### Test Results

**Density, Table 1**

<b>Processes</b>	<b>Density</b>
	(g/cc)
Control base process non infiltrated	6.88
Conventional Copper Infiltration	7.57
Infiltration by Copper stamping	7.62
Dual Feed material	7.57

The infiltration by copper stamping produced the highest density and is therefore a suitable replacement for powder metal infiltration. It may also be possible to use a wrought sheet material other than copper as the source of the infiltration material.

**Erosion/Cleanliness, Table 2**

<b>Process</b>	<b>Comments</b>
Control base process non infiltrated	As sintered
Conventional Copper Infiltration	Normal residue and erosion for this process
Infiltration by Copper stamping	Reduced erosion and minimal residue compared with conventional copper infiltration
Dual Feed material	Dual Feed creates the effect of more erosion compared to conventional copper infiltration

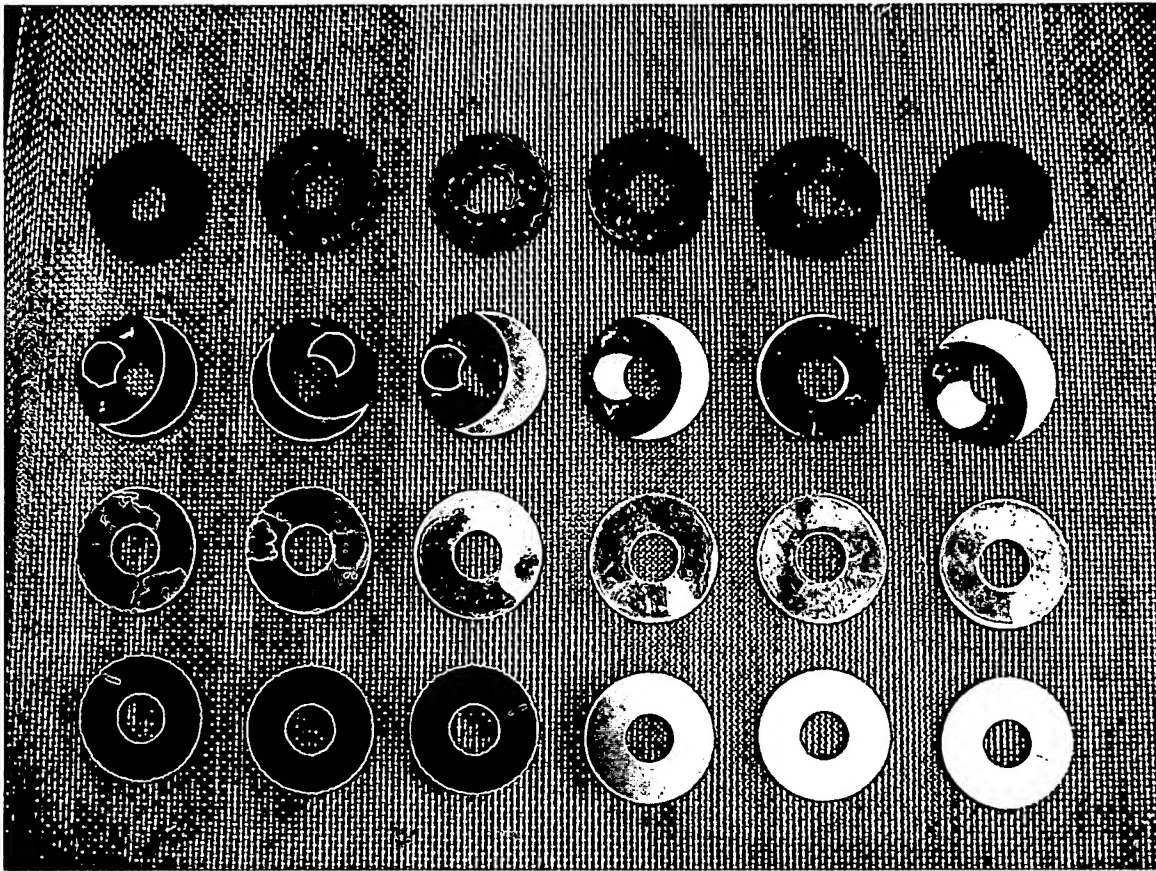
### **Conclusions**

1. Dual feeding of material was not a suitable method for infiltration of P/M articles.
2. Conventional copper infiltration produces significant residue and erosion. It is difficult to align the pressed copper infiltrant slug causing inconsistent infiltration. Due to the fragile “green strength of the pressed infiltrant material the infiltration process is subject to high scrap when the infiltrant slug is thin due to handling breakage.
3. Infiltration by copper stamping is a unique process and has the following advantages:
  - a. Is a low erosion infiltration process;
  - b. Is a low residue infiltration process;
  - c. Is a selective infiltration process by stamping shapes with geometry not practical via conventional powder metal infiltrant slugs such as thin webs and missing areas;
  - d. Using thin gauge copper materials eliminates the breakage associated with P/M infiltrant slugs, reducing scrap and improving quality; and
  - e. Allows the use of stamping location features such as “ears”, “lips” or other readily stamped orientation features.

**We Claim:**

1. A P/M copper infiltration process that utilizes copper sheet as the source for copper.
2. A P/M component processed in accordance with Claim 1 comprising the following steps:
  - a. Forming a P/M iron based component to a density in the range of 6.0 to 7.0 g/cc;
  - b. Forming a copper based infiltrant blank from wrought sheet material;
  - c. Assembling the iron based component and the copper based infiltrant sheet material blank; and
  - d. Sintering or heating the assembly of the iron based component and the copper based infiltrant sheet material blank to cause melting of the copper based material and infiltration into the porosity of the P/M iron based component.
3. A method as claimed in Claim 1, wherein the copper sheet is formed into an infiltration blank by a stamping or fineblanking process.
4. A method as claimed in Claim 3, wherein the infiltration sheet blank is further contoured with locating features to improve orientation or surface contact of the copper based infiltrant sheet material blank onto the P/M iron based component.
5. A method as claimed in Claim 2, wherein the infiltrant material is based on a material other than copper.

**Figure 1: Samples After Sintering/Infiltration.**



The top row is of the Dual Feed process. Following with the Standard ring with pressed copper rings set atop. The second from the bottom row is the standard ring with a pre-fabricated copper stamping set atop. The bottom row is the standard ring. Notice the amount of skull left on the top two rows. The pre-fabricated stamping leaves no skull.